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MECHANICAL SCARIFICATION AND STRIP CLEARCUTTING TO INDUCE LODGEPOLE PINE REGENERATION

ONE WEEK LOAN

By
D. I. Crossley

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Mechanical Scarification and Strip Clearcutting to Induce Lodgepole Pine Regeneration

Project A-23

BY

D. I. CROSSLEY

INTRODUCTION

Lodgepole pine *(Pinus contorta* Dougl. var. *latifolia* Engelm.) is recognized as a fire type that regenerates readily after the humus has been destroyed by fire and seed released from the serotinous cones opened by heat. However, a very wide variation in stocking is the usual result. From a study of the causes of variation in stocking on a large regenerated 16-year-old burn on the Kananaskis Forest Experiment Station in Alberta, Horton (1953) found that 25 per cent of the area was heavily overstocked and stagnating, and an additional 23 per cent was lightly overstocked and would probably stagnate in the future. He concluded that the usual tendency after fire was toward overstocking on the better sites.

Stagnation in lodgepole pine stands is a difficult condition for the silviculturist to overcome and the best defence against it appears to be the prevention of over-abundant regeneration. Apparently this precludes the use of fire, at least under natural conditions. Clearcutting on the Lewis and Clark National Forest in Montana (Anon. 1950) resulted in good regeneration of lodgepole pine both on the untreated forest floor and on the skid roads, with heavy slash inhibiting reproduction, and broadcast burning greatly curtailing it. Clearcutting in strips on the Kananaskis Forest Experiment Station, with piled slash, resulted in adequate but not superabundant regeneration (Crossley 1952), but success was credited to a poor site as reflected in a light surface litter and a scarcity of competing vegetation.

Whether similar results could be obtained on better sites in Alberta where the duff is heavier than in Montana and where competition from more luxuriant ground vegetation becomes an important factor remained to be proved. Eyre and Lebarron (1944) were unable to regenerate jack pine adequately without baring the mineral soil to seedfall and they accomplished this by mechanical means.

It is obvious when clearcutting in lodgepole pine stands that the seed to regenerate the site must come from one or both of the following sources: (1) from the serotinous cones in the slash, or (2) from the seed supply in the cones of the marginal stands.

Contrary to the popularly accepted belief, not all lodgepole pine trees bear their cones serotinously, nor are all cones on any one tree necessarily serotinous. Studies presently under way in Alberta (Crossley 1955) indicate that there is a light but continuous seed release from natural pine stands which reaches a maximum at the time of cone ripening in September each year.

The present study was designed to investigate the receptivity of the forest floor to lodgepole pine regeneration after strip clearcutting when mechanical scarification had bared the mineral soil, in comparison with the forest floor not specifically treated, each to be subjected to a seed supply from: (a) the marginal stands, and (b) marginal stands and the lopped and scattered slash.

METHODS

The area selected for this study was a portion of an 85-year-old stand of lodgepole pine on a very gently undulating plain situated in the foothills section of the boreal forest region at Strachan, in Alberta. According to Hills' (1952) physiographic classification, the site can be classified 4:1:3/1, i.e., the local climate is standard, the soil moisture regime is somewhat dry, and the material permeability somewhat rapid through the surface deposit of silt loam and very rapid through the underlying coarse-textured outwash material.

The stand is even-aged and its composition and structure are presented in Figure 1.

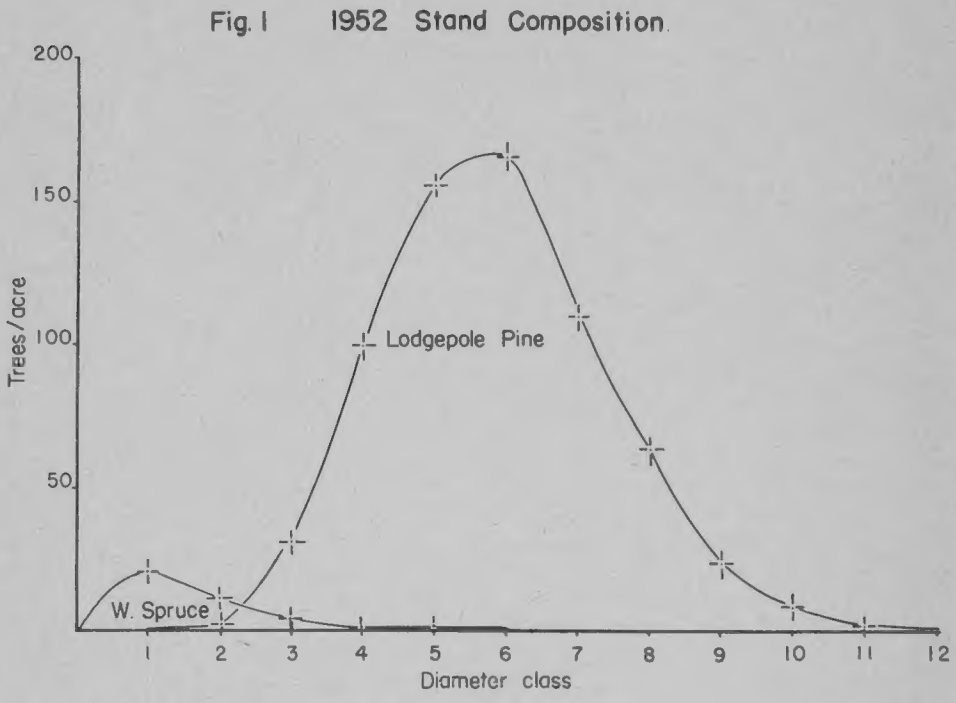

FIGURE 1. Stand composition in 1952.

The strips to be clearcut were 2 chains in width with an intervening chain-wide untouched residual stand, and were divided into 8 treatment units, 2 chains by 6 chains, to which four treatments were assigned at random (Figure 2).

The treatments selected for comparative study on the clearcut strips were as follows:

1. Forest floor unscarified, slash lopped and scattered.
2. Forest floor unscarified, slash removed by piling and burning.
3. Forest floor scarified, slash lopped and scattered.
4. Forest floor scarified, slash removed by piling and burning.

The eight units embracing the four treatments replicated twice were arranged in random order on the ground as presented in Figure 2.

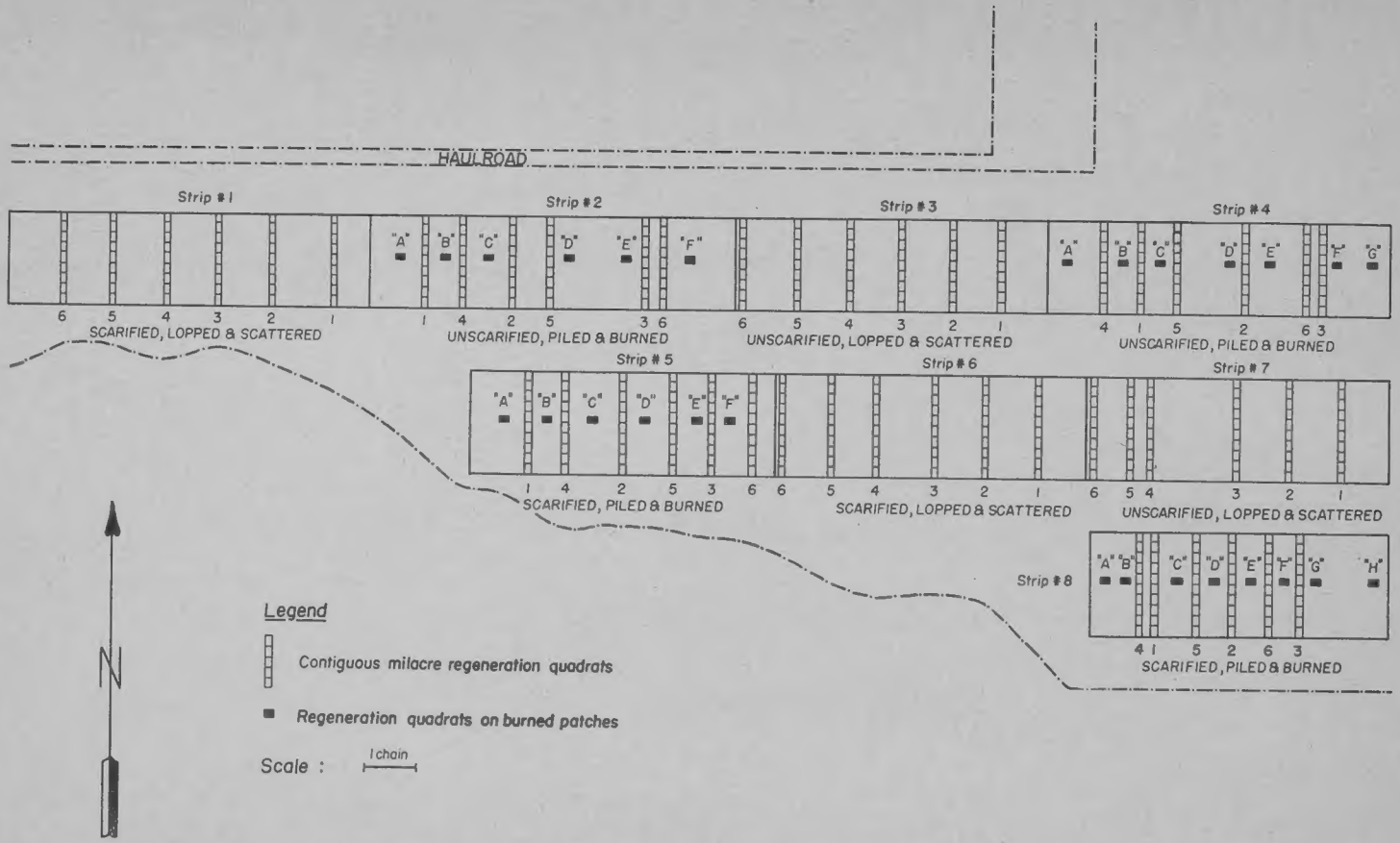

FIGURE 2.—Nature of regeneration study quadrats on clearcut strips.

In order to avoid the expense of handling the slash, the appropriate seedbeds (1, 5, 6, and 8) were prepared by scarifying prior to logging, using a Laurentide Beetle tractor with attached dozer blade. It is not suggested that such equipment is ideal for this work, but its narrow width did enable the operator to complete the task satisfactorily despite the presence of the untouched stand.

PLATE 1. The prescarified forest floor.

The results of the prescarification treatment are presented in Table 1. Bare mineral soil was tallied as "scarified". Where the litter was disturbed, leaving a mixture of humus debris and mineral soil, it was tallied as "disturbed". Treatment was completed during the month of June 1952.

TABLE 1. DEGREE OF MECHANICAL PRESCARIFICATION ACHIEVED ON THE FOREST FLOOR.

Strip No.	Scarified	Disturbed	Undisturbed
	Per cent	Per cent	Per cent
1	18·4	57·0	24·6
5	21·2	58·2	20·6
6	20·0	53·3	26·7
8	18·6	52·2	29·2
Average	19·5	55·2	25·3

The original intention was to have the timber cut immediately following scarification so that seed from slash-borne cones would be shed during the remainder of the summer and be available for germination the following spring (1953). Due to uncontrollable factors, cutting did not commence until January

of the following year (1953) and was completed in March. On the pertinent strips (2, 4, 5, and 8), slash was piled and burned during late May, 1954. On the remainder of the strips, slash had been lopped and scattered at the time of logging.

PLATE 2. Slash being piled preparatory to burning.

The purpose of removing the slash by piling and burning was primarily to eliminate the cones borne on the slash so that the seed would be available only from the marginal residual stands. However, it soon became apparent that the disposal of the slash did not necessarily mean disposal of all the cones originally borne by that slash. A great many of the cones broke off in the logging operations and during the task of piling the slash. The ground was littered with such cones, many of which were ideally situated to open and release seed (Crossley 1956). Since one of the objectives of the study was to determine the degree of success that could be expected from a marginal seed source, hand picking of these cones appeared to be the only answer to their removal, but to do so over the four units involved, presented a bigger task than could be undertaken. It was therefore decided to combine such an operation with the quadrats to be established for the study of future regeneration.

Six lines, 3·3 feet in width, were run at right angles to the long axis of each of the units (2, 4, 5, and 8). On lines numbered 1, 2 and 3, the cones were all removed by hand picking, and on lines 4, 5 and 6 they were allowed to remain. Each line was then divided into contiguous elongated milacre quadrats (3·3′ x 13·2′) for regeneration study purposes. Unfortunately the removal of all the cones from the specified lines did not entirely eliminate the possibility of some seed from that source, since a small percentage of cones had already opened by the time of removal.

The presence of burned patches on some of the strips, following piling and burning of slash, provided small areas where no seed could possibly have remained unconsumed by the fire. Any regeneration occurring on such locations would have to originate from seed flying in from the marginal stand. One half of the

available burned patches were therefore reserved for a regeneration study and on each a permanent milacre quadrat was established. Because of the possibility that an intensively burned seed-bed would be unreceptive to seed falling upon it, cone-bearing slash was placed on the remaining half of the available burned patches. Plates 3 and 4 illustrate the nature of such seed-bed study quadrats.

PLATE 3. Elongated milacre study quadrat located over ashes resulting from the burning of slash piles.

PLATE 4.—Quadrat similar to that shown in Plate 3, but with the addition of cone-bearing slash.

RESULTS

The success of regeneration studies such as this are often conditioned by the weather experienced during the study period. A Department of Transport weather station is maintained at Rocky Mountain House, 11 miles to the northeast of the experimental area, and its precipitation records are presented in the following table.

TABLE 2. MONTHLY PRECIPITATION AT ROCKY MOUNTAIN HOUSE

(in inches)

	May	June	July	August	September	Total
1953	3·2	6·7	5·6	3·6	1·0	20·1
1954	3·8	4·1	1·7	8·6	3·8	22·0
22-year mean	1·8	3·3	2·3	3·0	2·3	12·7

During the first season (1953), rainfall data were collected on the study area during the critical months of July, August and early September. Figure 3 illustrates the very favourable distribution experienced during that time.

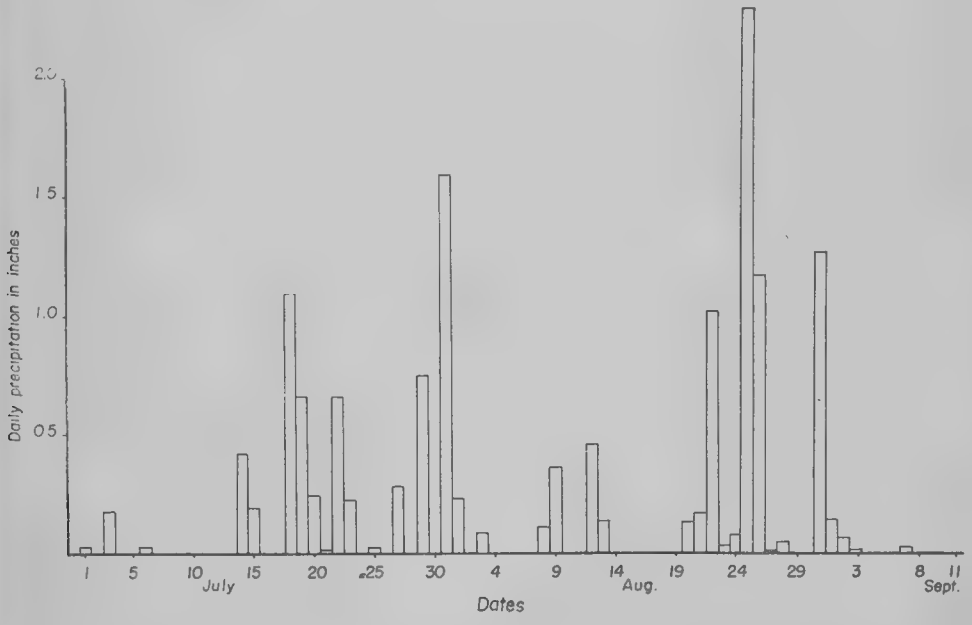

FIGURE 3.—Distribution of rainfall throughout the 1953 growing season.

Detailed tallies of regeneration were completed on the line plots in the autumn of 1953, and again in the autumn of 1954. The results are presented in Table 3.

TABLE 3. REPRODUCTION OF LODGEPOLE PINE BY MILACRE QUADRATS DURING THE TWO YEARS FOLLOWING SCARIFICATION

Strip No.	Treatment	1953 germinants in fall of 1953		1953 germinants in fall of 1954		1954 germinants in fall of 1954		1953 and 1954 germinants in fall of 1954	
		Per cent stocking	Av. surv. per stocked quadrat	Per cent stocking	Av. surv. per stocked quadrat	Per cent stocking	Av. surv. per stocked quadrat	Per cent stocking	Av. surv. per stocked quadrat
1 and 6	Prescarified, lopped and scattered	80·2	3·4	78·4	3·3	63·7	3·0	87·5	5·5
3 and 7	Unscarified, lopped and scattered	21·7	1·8	18·3	1·5	18·3	1·3	31·7	1·6
5 and 8	Prescarified, piled and burned;								
	a) cones removed	81·5	7·4	81·5	7·1	61·5	1·8	85·0	8·1
	b) cones present	78·5	5·0	76·5	4·8	68·5	5·0	93·3	7·6
2 and 4	Unscarified, piled and burned;								
	a) cones removed	22·0	1·8	22·0	1·8	9·0	1·0	29·6	1·8
	b) cones present	22·0	2·6	22·0	2·2	27·5	1·2	37·0	2·2

From the results presented in Table 3, several conclusions can be drawn.

1. Reproduction following prescarification was much superior to results where no pre-treatment was given.
2. Mortality over the first two years has been very light, regardless of treatment.
3. Germination during the second season was considerable, but served mainly to increase the number per stocked quadrat, rather than the percentage of stocked quadrats.
4. Little difference was apparent in reproduction results between lopping and scattering of the slash and piling and burning it, or between removal and non-removal of the cones.

TABLE 4. SURVIVAL RESULTS IN LODGEPOLE PINE REPRODUCTION ON THE BURNED PATCHES DURING TWO SEASONS

Treatment	Average Number of Stems per Stocked Milacre Quadrat	
	Fall of 1953	Fall of 1954
No slash	4·1	0·5
Cone-bearing slash	6·1	8·8

The conclusions to be drawn from the results presented in Table 4 are:

1. Since no seed was available from cone-bearing slash or from loose cones on the ground from the first method of treatment, the germinants must have resulted from seed that flew in from the marginal stands.
2. Mortality was heavy under black seed-bed conditions and in the absence of shade. The conduction of heat from the highly absorptive surface was undoubtedly responsible.
3. Slash provides the shade necessary for the survival of much of the germination that resulted from the seed shed by cones on the slash, as well as from seed that flew in from the marginal stands.

DISCUSSION

The results show that the seed-bed resulting from conventional winter horse-logging practices in pine was comparatively ineffective in obtaining reproduction. If we consider 60 per cent or greater stocking as acceptable, and less than 40 per cent as unsatisfactory, it is obvious that the untreated seed-beds have so far failed to regenerate the stand adequately. It will be recalled that scarification took place almost one year prior to the completion of logging. It is possible that fresher scarification would have resulted in denser regeneration.

On the other hand, some of the results obtained are puzzling. For example, why was regeneration so good at the conclusion of the first season? It was thought that most of the cones in slash laid down during the winter months would not open until the heat of the summer was reached, and seed falling on the forest floor at that time of year would not normally be expected to germinate until the following spring. The answer to this question might also throw light on the second point that arises, namely the excellent results obtained even when the slash and loose cones were removed from the scarified strips. Where did the seed come from to effect such results? The seed could have lain in the duff and germinated after duff disturbance and admission of the light and heat that followed clearcutting, or it could have originated in the marginal stands. Since duff-borne seeds could scarcely have survived intensive burning, the regeneration results obtained on the burned quadrats suggest that the seed supply came from the cones borne by the residual trees in the marginal stands. However, the burned quadrat sample was very small and the results are therefore unreliable. It is apparent that the data are not at hand to answer these questions and it is suggested that future research should be designed to gather the necessary additional information.

Scarification was followed by a vigorous invasion of annuals, chiefly fireweed, both where the slash was present and where it had been removed. In spite of this competition, the growth of the pine seedlings has been good and

PLATE 5. Invasion of fireweed at the conclusion of the second season.

this suggests that the annuals present were useful in providing a degree of shade, a factor which is particularly important in the absence of slash.

Burning apparently created a seed-bed favourable for germination but not for survival, unless some degree of shade was provided. Natural invasion of competing vegetation was slow and shade from such a source was therefore lacking. The photographs presented as Plates 3 and 4 were taken in the autumn of the second year and clearly illustrate such a lack.

The high degree of stocking obtained on all the scarified seed-beds is most gratifying, but what is equally satisfying is the moderate intensity of germination as illustrated by the average number of surviving seedlings per acre at the conclusion of the second season. Under acceptable degrees of stocking it ranges from 5,500 to 8,100 per acre, which is a far cry from the dense carpets of regeneration ranging to as high as one-quarter to one-half million seedlings per acre that are often a part of the pattern after natural fire. Some milacres supported as high as 32 germinants, but these occurred in 2 or 3 clumps around an open cone and were not spread uniformly over the milacre.

Of course it is by no means certain that regeneration has ceased at the conclusion of the second year. Horton (1953) found that after fire, the majority of pine seedlings became established within three years, but that "a noteworthy percentage 'came in' during the succeeding three years and some even later". However, he does suggest that after the first few years, new seedling establishment is only sufficient to compensate for annual mortality.

As has been pointed out, the rainfall experienced during the two years of study was abnormally high and, particularly during the first year, it was very well distributed throughout the growing season. Such conditions may have resulted in more than usual success on both the scarified and unscarified strips but it is suggested that more normal or even droughty climatic conditions would probably have the greater adverse effect on regeneration attempting to become established on the undisturbed duff. Further experimentation is necessary to verify the reproduction results in normal or drought years.

The important fact arising from this study is that both methods of slash disposal provided acceptable results, and as long as a marginal seed is available it is apparent that the method of slash disposal is not critical, and can be determined using other criteria such as expense or resulting fire hazard or both. What the results fail to reveal is the true significance of a marginal seed source. Could similar results be obtained on large cut-overs where reliance would have to be made solely on the seed stored in the cone-bearing slash?

The availability of a mineral soil seed-bed appears to be of prime importance for success, and in this particular investigation it was obtained by prescarifying. However, there is no reason to suppose that similar results could not have been obtained by post-scarifying, and if, as the data suggest, the presence of slash or its uniform distribution is not critical to success as long as a marginal seed source is present, then we are free to search for cheaper, more practical means of obtaining the same result. A most desirable situation would arise if skidding methods could be devised that would result in adequate scarification of the seed-bed. Failing the development of such a cheap method, the logging operation would have to stand the cost of known methods of scarification that would accomplish the desired results. One method at present in use in lodgepole pine on the National Forests in the United States is to combine the operations of scarifying the seed-bed and windrowing the slash. With proper equipment and adequate power, the work can be done effectively at a cost that can

be justified when one considers that fire hazard, the risk of a rise in insect populations, and the incidence of disease are thereby reduced or eliminated.

Mention should be made of the possibility of obtaining undesirable overdense reproduction if too thorough a job of scarifying is undertaken. Post-scarifying with heavy mechanical equipment is likely to result in almost 100 per cent baring of mineral soil, whereas the very favourable results of the present study were obtained by baring one-fifth of the seed-bed.

SUMMARY

The study was undertaken in a maturing, even-aged stand of lodgepole pine in Alberta and was designed to investigate the comparative receptivity of scarified and unscarified forest floors after the removal of the stand by clear-cutting in strips. Two sources of seed were made available through the lopping and scattering of cone-bearing slash and from the standing trees in the marginal residual strips.

The results two years after treatment, during which favourable weather conditions were experienced, may be listed as follows:

1. Prescarification is a feasible method of seed-bed treatment.
2. The only acceptable degree of stocking to lodgepole pine seedlings resulted after prescarification, and such seed-bed treatment was therefore a prerequisite to success.
3. With seed available from the marginal stands, the presence or absence of cone-bearing slash made very little difference in the results.
4. The design of the experiment and the data collected failed to establish the importance of cone-bearing slash as a source of seed.
5. Most of the germination occurred during the first year. While it was by no means inconsiderable during the second season, there was little increase in the percentage of stocked quadrats.
6. While germination will undoubtedly continue for several years, it is likely that it will at best just keep pace with mortality. In that event the intensity of reproduction can be regarded as satisfactory and the likelihood of eventual stagnation due to excessive numbers eliminated.
7. Since mechanical scarification is apparently so effective in obtaining the reproduction of the stand, some thought should be given to justifying the expense involved. If slash disposal to reduce or eliminate the hazards of fire, bark beetle infestations, and pathological diseases is part of the management plan, then windrowing by mechanical means can be effected so as to scarify at the same time, thus distributing the costs.
8. There is probably a close relationship between the percentage of scarified soil and the degree of stocking. Since density is such an important consideration, future research on the reproduction of lodgepole pine stands should attempt to establish this relationship.

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